The Effectiveness of Unconventional Monetary Policy: The Term Auction Facility

The Effectiveness of Unconventional Monetary Policy: The Term Auction Facility

Daniel L. Thornton*

Federal Reserve Bank of St. Louis

thornton@stls.frb.org

October 28, 2010

Abstract

This paper investigates the effectiveness of one of the Fed's unconventional monetary policy tools, the term auction facility (TAF). At issue is whether the TAF reduced the spread between LIBOR rates and equivalent-term Treasury rates by reducing the liquidity premium embedded in LIBOR rates. This paper suggests that rather than reducing the liquidity premium in LIBOR rates, the announcement of the TAF increased the risk premium in financial and other bond rates because market participants interpreted the announcement by the Fed and other central banks as a sign that the financial crisis was worse than previously thought. Evidence is presented that supports this hypothesis.

JEL classification: E52; E58; G14
Keywords: term auction facility, liquidity premium, counterparty risk, libor rate.

*The views expressed her are the author's and do not necessarily represent the views of the Board of Governors of the Federal Reserve or the Federal Reserve Bank of St. Louis. I would like to thank Massimo Guidolin, John Taylor, and Giorgio Valente for helpful comments and Aaron Albert for helpful research assistance.

1 Introduction

The Fed's actions in the wake of the financial crisis have spurred research into the effectiveness of unconventional monetary policy. One unconventional policy that has received considerable attention is the term auction facility (TAF). At issue is whether the TAF reduced the spread between London interbank offered rate (LIBOR) rates and equivalent-term Treasury or overnight indexed swap (OIS) rates. The Fed introduced the TAF based on the belief that the increase in the spread between term LIBOR rates and equivalent-term Treasury or OIS rates at the onset of the finanical crisis was due an increase in the liquidity premium. In announcing the TAF the Fed noted that "by allowing the Federal Reserve to inject term funds through a broader range of counterparties and against a broader range of collateral than open market operations, this facility could help promote the efficient dissemination of liquidity when the unsecured interbank markets are under stress."[1] In testimony before Congress on January 17, 2008, Chairman Bernanke (2008) indicated that "the goal of the TAF is to reduce the incentive for banks to hoard cash," i.e., reduce the liquidity premium that the Fed believed banks were requiring to lend in the interbank market. Christensen, Lopez, and Rudebusch (2009), hereafter CLR, summarize the intended effectiveness of the TAF by noting that,

> In theory, the provision of central bank liquidity could lower the liquidity premium on interbank debt through a variety of channels. On the supply side, banks that have a greater assurance of meeting their own unforeseen liquidity needs over time should be more willing to extend term loans to other banks. In

[1] Board of Governors of the Federal Reserve System, Press Release, December 12, 2007, http://www.federalreserve.gov/newsevents/press/monetary/20071212a.htm.

addition, creditors should also be more willing to provide funding to banks that have easy and dependable access to funds, since there is a greater reassurance of timely repayment. On the demand side, with a central bank liquidity backstop, banks should be less inclined to borrow from other banks to satisfy any precautionary demand for liquid funds because their future idiosyncratic demands for liquidity over time can be met via the backstop.[2]

Because the intent was to provide liquidity to banks most affected by the financial crisis rather than increase the total liquidity in financial markets, the Fed sterilized the effect of TAF lending on the total supply of credit by selling an equivalent amount of government securities. Thornton (2009) has noted that by sterilizing its lending, the Fed effectively forced the market to reallocate credit from other credit market participants to institutions that obtained loans through the TAF.

Taylor and Williams (2008ab, 2009) and others have argued that the increase in the interbank rate spreads was due to the increase in the risk premium, rather than to an increase in the liquidity premium. Economic theory suggests (e.g., Taylor and Williams, 2008a; and Thornton 2009) that because TAF lending was sterilized it could have no effect on the total supply of credit, expectations of future overnight rates, or counterparty risk. Consequently, if the increase in the inter-bank spreads is the consequence of an increase in the credit risk premium, the TAF would have no effect on it.

Empirical investigations of the efficacy of the TAF using standard regression, event-study methodology (e.g., Taylor and Williams, 2008ab, 2009; McAndrews, Sarkar, and Wang, 2008; and Wu, 2008) have yielded mixed results on the TAF's effectiveness. Recently, CLR

[2] Christensen, Lopez, and Rudebusch (2009), p. 2.

have presented evidence from a six-factor term structure model that indicates that the announcement effect of the TAF was a very large. Specifically, CLR conduct a counterfactual experiment and find that the announcement of the TAF reduced the liquidity premium in the 3-month LIBOR rate by 82 basis points relative to what the spread would have been otherwise.

This paper adds to the existing literature by showing that CLR's conclusion depends critically on the marked increase in the spreads between AA-rated financial bond rates and equivalent-maturity LIBOR rates immediately following the TAF announcement. I offer an alternative hypothesis for the marked increase in the financial bond/LIBOR rate spreads and present a variety of evidence that supports my hypothesis. I then show that nearly all of the behavior of the LIBOR-Treasury spread before and after the TAF announcement is accounted for by risk spreads. When these risk spreads are accounted for the TAF appears to have had little or no effect on the LIBOR-Treasury spread.

The remainder of the paper is as follows. Section 2 discusses the behavior of the spreads between term LIBOR rates and equivalent-term Treasury rates over the period 2007-2009 and reviews the event-study empirical literature. Section 3 presents CLR's affine-term-structure-model approach for analyzing the effect of the TAF on the LIBOR-Treasury spread. The analysis shows that CLR's announcement effect is due entirely to the marked increase in highly rated corporate financial bond rates relative to LIBOR immediately following the announcement of the TAF. Section 4 offers an alternative hypothesis for the marked change in the spread between these rates and presents evidence that is consistent with this hypothesis. An analysis of the LIBOR-Treasury spread and various risk spreads and the effect of the TAF on the LIBOR-Treasury spread is presented in Section 5. The conclusions are presented

in Section 6.

2 Event-Study Investigations of the Effects of the TAF

Figure 1 shows the daily spread between the 3-month LIBOR and T-bill rates from January 2, 2007 through December 31, 2009. The spread began increasing in April 2007, on news of problems with subprime loans in the mortgage market to a peak of over 100 basis points in late June 2007.[3] The spread then increased dramatically on August 9, 2007, when BNP Paribas, France's largest bank, halted redemption on three investment funds (the financial crisis is assumed to begin on this date). The spread then cycled around an average of about 140 basis points until mid-summer 2008, when it declined and cycled around 100 basis points of so. The spread increased dramatically again on September 15, 2008, when Lehman Brothers filed for Chapter 11 bankruptcy protection; it increased to a peak of 452 basis points on October 10, 2008, but declined and stabilized around 100 basis points by early January 2009. The spread began drifting lower by mid-April 2009 and stabilized near its pre-financial crisis level of about 15 to 20 basis points by early September 2009. The Fed argued that the dramatic increase in the spread in August 2007 reflected an increase in banks' liquidity premium, i.e., banks were demanding a higher rate on interbank loans because of an increased demand for liquidity. Alternatively, one might argue that the increase in the LIBOR spread was a consequence of a perception that lending to banks had become more risky, i.e., there was an increased risk of default. Consequently, at issue is whether the increase in the LIBOR spread associated with the financial crisis was due to an increase in a

[3]For a complete time line of events during the financial crisis go to http://timeline.stlouisfed.org/index.cfm?p=timeline#.

liquidity premium or an increase in the credit risk premium and, importantly, whether the TAF reduced the spread.

Taylor and Williams (2008a) were the first to investigate whether the TAF had a significant effect on LIBOR rate spreads. They investigated the effect of the TAF by regressing the 1- and 3-month spreads between the LIBOR and OIS rates on various measures of counterparty risk and dummy variables for TAF bid submission dates. In all of the cases considered, the coefficient on the measure of counterpart risk was positive and statistically significant, indicating that some of the increase in the spread was accounted for by risk premiums. The coefficients on the TAF dummy variable were also positive, but not statistically significant. Based on their economic and empirical analyses, Taylor and Williams (2008a) concluded that "increased counterparty risk between banks contributed to the rise in spreads and find no empirical evidence that the TAF has reduced spreads."[4]

McAndrews, Sarkar, and Wang (2008) investigate the effect of the TAF on the LIBOR-OIS spreads using a regression methodology similar to that of Taylor and Williams (2008a). However, they suggested that Taylor and William's use of the level of the spread in their regressions "is valid only under the assumption that the liquidity risk premium falls on a day with a TAF event but reverts to the previous level immediately after the TAF event."[5] Using the change in the spread as the dependent variable and using dummy variables for all of the various auction announcements and operations, they found that the TAF significantly reduced the size of the LIBOR-OIS spreads.

Wu (2008) suggests that the methodology used by Taylor and Williams (2008a) and

[4] Taylor and Williams (2008a), title page.
[5] McAndrews, Sarkar, and Wang (2008), p. 10.

McAndrews, Sarkar, and Wang (2008) is problematic because (a) they assume that the TAF had no effect on the spread other than on event days associated with it, (b) they do not control for "systematic counterparty risk among major financial institutions," and (c) they fail to separate the effects of "lowering the counterparty risk premiums from those relieving liquidity concerns."[6]

Wu's (2008) approach to analyzing the effectiveness of the TAF differs from the two previous approaches in three respects. First, rather than using a dummy variable for the TAF on specific event days, Wu's TAF dummy variable is zero for all days prior to the announcement of the TAF on December 12, 2007, and one thereafter. Wu (2008) argued that because TAF lending was for maturities of 28 days or longer, "one would expect that such loans would be able to relieve the financial strains for the duration of the loans," and not simply effect the spread on specific event days. Wu also included alternative measures of stock and bond market volatility, and the Euro-dollar rate volatility as well as "mortgage default risk factor" in his regression equations.[7] In contrast to the findings of Taylor and Williams (2008a), Wu finds that "the TAF has, on average, reduced the 1-month LIBOR-OIS spread by at least 31 basis points, and the 3-month LIBOR-OIS spread by at least 44 basis points." He also regressed his TAF dummy variable on two measures of "systematic risk" and, consistent with Taylor and Williams' analysis, found that the coefficient is positive and statistically significant, suggesting that the TAF has "not been able to reduce the counterparty default risk premiums."[8]

Taylor and Williams (2008b) reacted to work by McAndrews, Sarkar, and Wang (2008)

[6] Wu (2008), p. 3.

[7] The mortgage risk factor is the first principal component for credit default swap rates for three mortgage companies.

[8] Wu (2008), p. 2.

and Wu (2008) and other criticisms in several ways. First, they showed that the spread between the LIBOR-OIS rates was very similar to the spread between the LIBOR rate and repo rate on government securities, arguing that the "LIBOR-repo spread is a very good measure of inter-bank risk because it is the difference in rates between secured and unsecured lending between banks at the same maturity."[9] The close correspondence between these rates suggests that the LIBOR-OIS spread primarily reflects credit risk and not liquidity risk.

They also suggested that one could discriminate between liquidity risk and counterparty risk comparing the behavior of rates paid to others who lend to banks but are not liquidity constrained, such as the rates paid on certificates of deposit. Term certificates of deposit, CDs, and term LIBOR loans are alternative ways that banks finance their shorter-term lending . Because purchasers of CDs are not liquidity constrained, there is no reason for CD rates to increase because of liquidity concerns. However, because these instruments are uninsured, CDs rate will rise when market participants believe that lending to banks is more risky. Consequently, the TAF should have no effect on any liquidity premium embedded in CD rates. Taylor and Williams (2008b) note that CD rates have tracked LIBOR rates of comparable maturities very closely, "suggesting that liquidity risk is not a significant separate factor driving term lending rates."[10] They also did additional regression analysis altering the timing of how the TAF might affect interest rates and using CD rates based on a broader set of banks and conducted regression analysis with the spreads between the CD, term federal funds, and Euro-dollar rates and the OIS rate as the dependent variable. They found no evidence of a significant effect of the TAF in any of these regressions.

[9] Taylor and Williams (2008b), p. 6.
[10] Taylor and Williams (2008b), p. 10.

In addition, Taylor and Williams found the results using Wu's (2008) TAF dummy variable were fragile. Specifically, the coefficient was large and statistically significant over one sample, but not when the sample was extended.[11] They also investigated the effectiveness of the TAF using the outstanding TAF loan balance. The estimated coefficients were sometimes negative, but seldom statistically significant.

Finally, they found that the results using the first difference of the spread rather than the level of the spread depended critically on the timing of the variable in the regression and on the particular TAF events considered. Noting that the relationship between LIBOR-OIS spreads and various measures of counterparty risk are robust, they conclude that "while other researchers have found significant TAF effects by altering the specification of the empirical equation that we originally proposed, these results are sensitive to small changes in specification, measures of the spread, or measures of risk."[12]

3 The Effectiveness of the TAF: Results From a Six-Factor Term Structure Model

Noting that the conclusion about the effectiveness of the TAF using regression analyses of Taylor and Williams (2008ab), McAndrews, Sarkar, and Wang (2008), and Wu (2008) are sensitive to "only small differences in the specifications of their regression equations," CLR use a very different approach.[13] Specifically, they analyze the effectiveness of the TAF by estimating a six-factor arbitrage-free term structure model based on a Nelson and Siegel

[11] Also see Taylor and Williams (2009), which reflects work from both of their 2008 papers.
[12] Taylor and Williams (2008b), p. 20.
[13] Christensen, Lopez, and Rudebusch (2009), p. 4.

(1987) yield curve. There are three Nelson-Siegel factors for Treasury yields, two Nelson-Siegel factors for bank bond yields, and a single LIBOR rate factor. They estimate the model using weekly data over the sample period January 6, 1995, to July 25, 2008. They note that their LIBOR factor changed significantly immediately following the announcement of the TAF (December 14, 2007) as did parameters of their model that involve the LIBOR factor. They then conduct a counterfactual experiment to quantify the effect of the change in the model's behavior for the 3-month LIBOR rate. Specifically, they fixed the mean of the LIBOR factor at its pre-announcement level and left the other factors unchanged. Their counterfactual experiment suggests that the 3-month LIBOR rate would have been an average of about 80 basis points higher without the TAF. Hence, they conclude that had the Fed not introduced the TAF, the spread of the 3-month LIBOR rate over the 3-month T-bill rate "would have been even higher than the observed historical spread."[14]

Given the sensitivity of the regression approaches to the specification of the equations, CLR's counterfactual result is the most compelling evidence that the TAF had a significant effect of reducing the LIBOR spreads. Consequently, it is important that this evidence be analyzed carefully.

CLR's counterfactural result depends critically on their LIBOR factor which is, in turn, based on the spreads between the 3-, 6-, and 12-month LIBOR rates and rates on AA-rated financial corporate bonds with the same maturities. Given that CLR assume that the LIBOR is independent of the other five factors it is not surprising to find that their LIBOR factor differs little from the first principal component obtained from the spreads between the LIBOR and AA-rated financial bond rates with maturities of 3, 6, and 12 months. This is

[14]Christensen, Lopez, and Rudebusch (2009), p. 29.

shown in Figure 2, which presents CLR's LIBOR factor and the first principal component of the three rate spreads. The vertical line denotes December 14, 2007 (the week of the TAF announcement). The two factors behave very similarly. Most importantly, both decline markedly immediately following the announcement of the TAF. The marked decline in the LIBOR factor is a consequence of the fact that AA-financial bond rates increased significantly relative to equivalent-term LIBOR rates immediately following the TAF announcement. This is illustrated in Figure 3, which shows the spread between the 3-month AA-rated financial corporate bond rate and the 3-month LIBOR rate weekly over CLR's sample period, January 6, 1995-July 25, 2008.[15] Both rates fell on the announcement, but the LIBOR rate declined more than AA-financial bond rates.

Because this marked and very persistent increase in the spread of AA-financial bond rates over LIBOR rates is responsible for CLR's counterfactural result, it is important to understand why highly rated financial bond rates increased relative to the LIBOR rates following the TAF announcement. CLR suggest that the decline in LIBOR rates relative to financial bond rates is due to a marked reduction in the liquidity premium that banks required to lend in the interbank market. Specifically, CLR suggest that "the bank bond rates are derived from debt obligations issued to a broad class of investors that overwhelmingly consists of nonbank institutions. While these two classes of lenders most likely attach similar probabilities and prices to credit risk, they likely have different tolerances to liquidity problems."[16] That is, the spread widened because of a marked decline in the liquidity premium in the LIBOR rates relative to AA-rated financial bond rates.

[15] The behavior of the 6- and 12-month spreads is very similar to that of the 3-month spread. Indeed, the first principal component of these three spreads accounts for 84 percent of the variance of the three spreads.

[16] CLS (2009), p. 26-27.

4 An Alternative Hypothesis for the Behavior of the Corporate Financial Bond-LIBOR Spread

Before presenting an alternative hypothesis for the behavior of the spread of the AA-financial bond rates over LIBOR rates, it important to note that there are several reasons to be skeptical of CLR's interpretation that are independent of this hypothesis. For example, it is important to note that if the sharp increase in the spread of AA-financial corporate bond rates over LIBOR rates were due to a decline in the liquidity premium required by banks, the same logic would imply that this spread should have declined markedly at the beginning of the financial crisis because the liquidity premium required by banks would have increased relative to that of the financial bond rate. This did not occur. Indeed, Figure 3 shows that rather than decreasing at the onset of the financial crisis as this hypothesis suggests, the spread increased sharply in late June 2007. The rise in this spread is difficult to reconcile with the idea that there was an increase in the liquidity premium associated with interbank lending as a consequence of the financial crisis.

Moreover, CLR's logic would suggest that there should have been a comparable increase in the spread between 3-month CD and LIBOR rates because CDs represent loans to banks by *a broad class of investors that overwhelmingly consists of nonbank institutions.* Figure 3, which also plots the spread of the 3-month CD rate over the 3-month LIBOR rate, shows that the CD-LIBOR rate spread did not increase dramatically following the TAF announcement. The CD-LIBOR spread increases by only a few of basis points after the TAF announcement, suggesting that there was essentially no effect of the TAF announcement on the liquidity premium associated with inter-bank lending.

4.1 The Alternative Hypothesis

These reasons for skepticism are supplemented by the fact that there is a credible hypothesis that can account for the increased spread between the AA-rated financial bond rates and equivalent-maturity LIBOR rates immediately following the TAF announcement.[17] Specifically, it is possible that the market participants interpreted the Fed's announcement of the TAF as an indicator that financial crisis was more serious than previously thought. This hypothesis seems particularly credible given that the Bank of England, the Swiss National Bank, the Bank of Canada, and the European Central Bank announced "measures designed to address elevated pressures in short-term funding markets" on that day. If market participants believed these announcements signaled that the financial crisis was worse than previously thought, the TAF and other announcements could have caused a reassessment of the credit risk of financial firms, increasing the spread between financial corporate bond rates and LIBOR rates.

4.1.1 Evidence Supporting the Alternative Hypothesis: The Behavior of Risk Spreads

This hypothesis is supported by the fact that spreads between financial and non-finanical corporate rates increased following these announcements. This is illustrated in Figure 4, which shows the spread between the 3-month AA-rated corporate financial bond rate and 3-month AA-rated corporate industrial bond rate over the sample period. The vertical

[17] There were reports that the LIBOR rate (which is obtained from surveys) was understating the rate that banks were actually paying in the interbank market during the financial crisis, e.g., Mollenkamp and Whitehouse (2008). Kuo et al., (2010) provide evidence supporting these claims. However, their estimates of the degree of understatment during this period is not large enough to account for CLR's findings.

black line denotes December 14, 2007, and the vertical dashed line denotes the onset of the financial crisis, August 10, 2007. This spread increased significantly at the onset of the financial crisis, suggesting an increase in the market's perception of the credit risk premium associated with investing in financial corporations. This spread initially declined following the TAF announcement, but then increased significantly. A similar pattern holds for the spreads between corporate financial and retail or utility bonds, suggesting that the risk premium associated with investing in financial corporations increased significantly in the wake of the financial crisis and shortly after the TAF announcement. The behavior of these spreads is consistent with the possibility that the increase in the AA-financial bond rates relative to comparable LIBOR rates could be the consequence of an increase in the credit risk premium for financial corporations following the December 14, 2007, announcements.

The hypothesis is further supported by the fact that non-financial corporate bond rates increased relative to LIBOR rates immediately following the TAF announcement. This is illustrated in Figure 5, which shows the spreads between 3-month AA-, A-, and BBB-rated industrial bond rates and the 3-month LIBOR rate. Unlike the spread between bank bond rates and LIBOR, which increased at the onset of the financial crisis, these spreads declined; LIBOR rates increased while industrial bond rates remained essentially unchanged. Consistent with the hypothesis that the TAF announcement signaled a worsening of the financial crisis, all of the spreads increased significantly following the TAF announcement. Moreover, the spreads for lower-rated bonds increased relative to those on higher-rated bonds. Hence, that announcement of the TAF and the other central banks' announcements appears to have increased the credit risk premium associated with making financial investments generally.

The hypothesis is also supported by comparing the spread between the 3-month AA-rated financial bond rate and the 3-month LIBOR rate with the spread between 3-month BBB-rated industrial bonds and the 3-month LIBOR rate. These spreads are shown in Figure 6 using weekly data for the period January 6, 1995, through July 25, 2008. The correlation between these two spreads is 77.8 percent prior to the 2001 recession, suggesting that much of the variation in the financial-LIBOR spread over this period was due to changes in market participants' perception of credit risk. During the recession and for a time thereafter the relationship is weaker. However, the relationship strengthens again in the mid-2000s and the correlation is 76.1 percent from the first week of 2005 to end of the sample period. Most importantly, both spreads increase dramatically and by nearly the same amount immediately following the announcement of the TAF. This suggests CLR's counterfactual result supporting the efficacy of the TAF may be the consequence of an increase in the risk premium for investing in AA-rated financial corporations rather than a decrease in banks' liquidity premium.

4.1.2 Evidence Supporting the Alternative Hypothesis: The Behavior of Corporate Financial and Bank Bond Spreads

The increased-risk-premium hypothesis is also consistent with the relative behavior of corporate financial and bank bond rates. Figure 7 shows the spread between 3-month AA-rated financial and 3-month AA-rate bank bond rates. The data are weekly and cover the period March 17, 2000, through July 25, 2008.[18] The vertical dashed line denotes the onset of the financial crisis and the vertical solid line denotes the announcement of the TAF. The

[18] Data on AA-rated bank bond rates are not available until March 17, 2000.

spread fluctuates around zero until the onset of the financial crisis when corporate financial bond rates increased relative to bank bond rates. The spread increases further shortly after the announcement of the TAF. This behavior is consistent with the hypothesis that the announcement increased the credit risk associated with investing in financial corporate bonds for two reasons. First, the implicit guarantee to bank investors associated with too-big-to-fail was thought to not apply to non-bank financial corporations, at least before the Bear Sterns bailout. Second, financial corporations had greater exposure to mortgage-backed securities (MBS) than did banks generally.[19] For both of these reasons, it is reasonable to expect that financial corporate bond rates would rise relative to bank bond rates.

This interpretation is consistent with the behavior of this spread following Lehman Bros. announcement that it was filing for Chapter 11 bankruptcy protection on September 15, 2008. Figure 8 presents this spread for the period January 4, 2008 through December 25, 2009. The vertical line denotes September 19, 2008. After declining from a peak of about 150 basis points in early April 2008, to zero just prior to Lehman's announcement, the spread increased markedly, reflecting an increase in the risk premium on corporate financial bonds relative to bank bonds.

4.1.3 Evidence Supporting the Alternative Hypothesis: CLR's LIBOR Factor and Risk Spreads

The analysis above strongly suggests that CLR's Libor factor reflects a marked change in the risk premium rather than a marked change in the liquidity premium as they hypothesize. Figure 9 shows CLR's Libor factor over the period March 17, 2000, through July 25, 2008.

[19] Of the $4.4 trillion of agency and GSE-backed securities held by financial institutions in the second quarter of 2007, only $1.1 trillion was held by banks.

The factor is more variable till early 2003 when there is marked reduction in variability. The variability increases again at the on set for the financial crisis. To see how much of the variation in CLR's Libor factor can be accounted for by risk premiums, it is regressed on risk premiums reflected in the spreads between BBB-rated and AA-rated corporate bank and industrial bond rates. The spreads are for maturities of 3, 6, and 12 months, the same maturities that CLR used to obtain their Libor factor. The sample period begins with the availability of AA-rated bank bond rate data, March 17, 2000. These six risk premiums account for 44 percent of the weekly variation in CLR's Libor factor over the sample period March 10, 2000, through July 25, 2008.

To see whether these risk premiums account for more or less of the variation when during periods when the Libor factor is relatively more variable and especially following the announcement of the TAF, the regression equation is estimated using a rolling window of 60 weeks. Figure 10 presents the rolling window regression estimates of $\bar{R}^2$ over the sample period. The data are plotted on the last week in the sample. The vertical line denotes the first sample to include post-TAF-announcement data. The estimates show that the risk premiums account for relatively more of the variation in CLR's Libor factor when it is particularly variable. For example, between 2001 and 2003 risk premiums account for over 80 percent of the variation for a period of a year or longer. Importantly, for the issue of whether CLR's counterfactual results are evidence of the success of the TAF in reducing liquidity premiums, the estimate of $\bar{R}^2$ increases dramatically when post–TAF-announcement data is included in the sample. The peak in the estimate of $\bar{R}^2$ of 82 percent is for the 60-week period ending April 4, 2008.

It may also be the case that the sharp increase in the spread of LIBOR rates over

equivalent-maturity Treasury rates was at least partly due to an increase in the risk premium associated with bank lending. To investigate this possibility, the spread between the 3-month LIBOR and T-bill rates was regressed on the same six risk premiums over the identical sample period. The risk premiums account for 50 percent of the variation in the LIBOR/T-bill spread over the entire sample period. Figure 11, which plots the 60-week rolling estimate of $\bar{R}^2$ for a regression of the LIBOR/T-bill spread on the six risk premiums, shows that after declining to essentially zero, the estimate of $\bar{R}^2$ increased dramatically following the onset of the financial crisis (denoted by the solid vertical line). It continued to increase to a peak of nearly 70 percent following the announcement of the TAF (denoted by the dashed vertical line). However, the estimate declined shortly after the TAF, suggesting the possibility that the TAF had some effect on reducing the LIBOR/T-bill spread that is not accounted for by these risk premiums. In any event, these estimates suggest that well over half of the increase in the LIBOR/T-bill rate spread following the onset of the financial crisis can be attributed to an increase in counterparty risk.

5 Explaining the Behavior of the LIBOR-Treasury Spread

The analysis in the previous section suggests that CLR's Libor factor is largely accounted for by risk premiums and, therefore, does not present strong support for the effectiveness of the TAF. However, the evidence using weekly data suggests that the TAF may have been effective in reducing the LIBOR/T-bill spread. This issue is investigated more thoroughly in this section using daily data.

The LIBOR/T-bill spread reflects both risk and liquidity premiums. The same is true

of the spread between corporate bond rates and equivalent-maturity corporate bond rates. A good way to assess the effect of the TAF in reducing the liquidity premium associated with the LIBOR/T-bill spread is estimate the effect of the TAF on the LIBOR/T-bill spread conditional on the spread between equivalent-maturity corporate and Treasury rates. Hence, this section analyzes the behavior of the 3-month LIBOR/T-bill spread using three 3-month corporate/T-bill spreads and 3-month CD/T-bill spread. The corporate/T-bill spreads are for corporate bank, industrial, and retail bonds. These spreads are denoted $BT3$, $IT3$, and $RT3$, respectively. The CD/T-bill and LIBOR/T-bill spreads are denoted $CDT3$ and $LT3$, respectively. Figure 12 shows the daily $LT3$, $BT3$, $IT3$, and $RT3$, over the period March 10, 2000, through April 13, 2010. The solid vertical line denotes December 12, 2007, and the dashed vertical line denotes September 15, 2008. The figure suggests that these spreads are highly correlated over the entire sample period. Indeed, a simple linear regression of $LT3$ on the other three spreads yields an estimate of $\bar{R}^2$ of 0.77. There is a marked drop in $LT3$ following the announcement of the TAF that is not reflected in the other three spreads, suggesting that the announcement of the TAF had an effect that was unique to the 3-month LIBOR rate. This effect was temporary, however. After reaching a local minimum of 84 basis points on February 12, 2008, the $LT3$ increased to the level of the other spreads (about 150 basis points) by late March 2008 and then followed the path of the other spreads closely thereafter. It is interesting to note, however, that $LT3$ also declined relative to the other spreads immediately following the Fed's massive injection of reserves into the banking system following Lehman Bros.'s September 15, 2008, announcement. The other spreads subsequently declined and by late March 2009 there was virtually no difference between $LT3$ and $RT3$. Consequently, it is not clear whether the reduction in $LT3$ immediately following

the TAF announcement reflects a reduction in the liquidity premium in the 3-month LIBOR rate or is simply a temporary reduction that occurred in expectation that the Fed would significantly increase the supply of reserves.

There are several reasons to doubt that it reflects a decline in the liquidity premium. First, there was no dramatic rise in $LT3$ relative to these spreads at the onset of the financial crisis, as would be the case if there was a marked increase in the liquidity premium in the LIBOR rate. Second, the behavior of $LT3$ and $CDT3$ is nearly identical before and after December 12, 2007, and September 15, 2008. This is illustrated in Figure 13, which shows these spread over the March 10, 2000-April 13, 2010 sample period. Both spreads increased dramatically and by nearly identical amounts at the onset of the financial crisis and declined sharply and by nearly identical amounts following both December 12, 2007, and September 15, 2008. Because the suppliers funds in the CD market are not liquidity constrained, the nearly identical behavior of these spreads combined with the very similar behavior of the corporate-Treasury spreads, and the fact that $LT3$ did not increase unusually at the onset of the financial crisis suggest that the TAF had little or no effect on the liquidity premium in LIBOR rates.

Nevertheless, this possibility is investigated further by estimating the equation

$$LT3_t = \alpha + \beta_b BT3_t + \beta_i IT3_t + \beta_r RT3_t + DUMVEC\delta + \epsilon_t,$$

where $DUMVEC$ is a vector of dummy variables that reflect important TAF dates used in the previous event-study literature and ϵ_t is an i.i.d. error term. Initially, $CDT3$ is not included on the r.h.s. of the equation because the very high correlation between $CDT3$ and

$LT3$ would reduce the likelihood that any of the TAF dummy variables would be statistically significant. To make the results comparable to the previous event studies, different sets of dummy variables, identical to those used by Taylor and Williams (2008ab), McAndrews, Sarkar, and Wang (2008), and Wu (2008), are used. There are six dummy variables. The first five are those used by McAndrews, Sarkar, and Wang (2008): the dates of international announcements related to the TAF (ANI), domestic TAF announcements (AND), dates when the conditions of the announcement were set (CON), when the auction took place (AUC), and when the results were notified (NOT).[20] The sixth dummy variable is that use by Wu (2008), denoted Wu, which is zero before December 12, 2007, and 1 thereafter.

The results are presented in Table 1.[21] The p-values are based on HAC standard errors. The results in the first two columns use McAndrews, Sarkar, and Wang's (2008) dummy variables. The results indicated that $LT3$ is significantly related to each of the corporate bond spreads. The coefficients on each bond spread are highly statistically significant. Moreover, the sum of the coefficients is 0.92 and the hypothesis that the sum of the coefficients is 1 is not rejected at the 5 percent significance level. The estimates of the coefficients on TAF dummy variables provide no evidence that the TAF had any significant effect on the LIBOR-Treasury spread. The coefficients on the ANI and AND dummy variables are positive, but not statistically significant. The coefficients on TAF operation dummy variables are negative, but not statistically significant. The results in the next two columns show that the conclusion does not change when the ANI and AND are combined.

There is some evidence that the TAF is effective in reducing the LIBOR-Treasury spread

[20] These dates can be found in McAndrews, Sarkar, and Wang (2008), Table 1, p. 20.

[21] The sample ends on April 30, 2008, to make the TAF sample period similar to that used by McAndrews, Sarkar, and Wang (2008) and Wu (2008).

when Wu's dummy variable is included. The estimate of the coefficient on Wu suggests that $LT3$ was an average of 34 basis points lower after the announcement of the TAF. However, as Taylor and Williams found, the coefficient on Wu tends to decline and becomes statistically insignificant as the length of the sample increases. Moreover, evidence of the effectiveness of the TAF using this dummy variable all but disappears when $CDT3$ is included. The estimate is negative and statistically significant at slightly higher than the 5 percent significance level when $CDT3$ is included, but the magnitude of the effect is only 3 basis points.

6 Conclusions

This paper reviews the previous literature on the effectiveness of the TAF in reducing the spread between equivalent-maturity LIBOR and Treasury rates and further investigates the effectiveness of the TAF using weekly and daily data. The previous literature using event-study methodologies finds mixed results. The most compelling evidence for the effectiveness of the TAF comes from CLR's (2009) six-factor term structure model. Doing a counterfactual analysis based on a marked change in the Libor factor of their model, CLR indicated that the 3-month LIBOR/T-bill spread would have been 82 basis points higher were it not for the TAF. Noting that CLR's Libor factor is based on the spread between AA-rate financial corporate bond rates and LIBOR rates, I show that these spreads are highly correlated with risk spreads, especially during the post-TAF-announcement period.

I offer an alternative hypothesis for the behavior of the spread between AA-rated financial corporate bond rates and LIBOR rates following the announcement of the TAF. Specifically, I hypothesize that market participants revised up their expectations of the seriousness of

the financial crisis in the wake of the TAF announcement and the announcements of other central banks. I present evidence from a variety of risk spreads that is consistent with this hypothesis, including the fact that over 80 percent of CLR's Libor factor is accounted for by risk spreads during this period. This suggests that much of the effect of the TAF which CLR report is actually due to an increase in the risk premium on financial bonds rather than a reduction in the liquidity premium embedded in LIBOR rates.

I then show that the majority of the 3-month LIBOR/T-bill spread before and after the TAF announcement can be accounted for by the spreads between financial and nonfinancial corporate bond rates. Further analysis using daily data indicates that controlling for these risk premiums, TAF appears to have had little or no effect on the 3-month LIBOR/T-bill spread.

References

Bernanke, B.S. (2008), "The Economic Outlook," testimony before the Committee on the Budget, U.S. House of Representatives, January 17, 2008.

Christensen, J.H., J.A. Lopez, and G.D. Rudebusch. (2009), "Do Central Bank Liquidity Facilities Affect Interbank Lending Rates?" Federal Reserve Bank of San Francisco Working Paper 2009-13.

Kuo, D., D. Skeie, and J. Vickery. (2010), "How well did Libor measure bank wholesale funding rates during the crisis?" unpublished manuscript, Federal Reserve Bank of New York, July 30, 2010.

McAndrews, J., O. Armantier, and S. Krieger. (2008), "The Federal Reserve's Term Auction Facility," Federal Reserve Bank of New York *Current Issues in Economics and Finance*, 14(5), 1-10.

Taylor, J.B., and J.C. Williams. (2008a), "A Black Swan in the Money Market," Federal Reserve Bank of San Francisco, Working Paper Series, 2008-04.

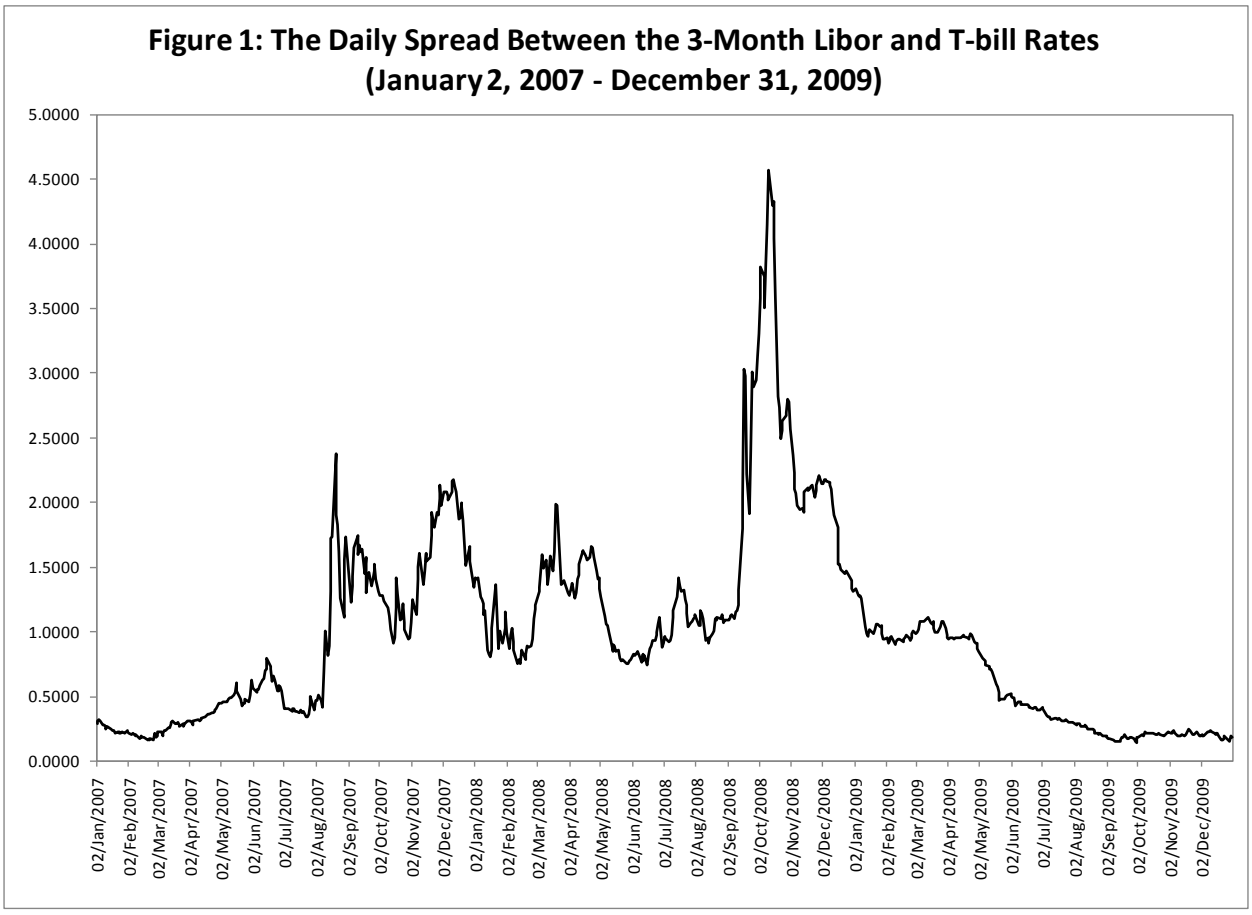
Taylor, J.B., and J.C. Williams. (2008b), "Further Results on a Black Swan in the Money Market," SIEPR Discussion Paper No. 07-046.

Taylor, J.B., and J.C. Williams. (2009), "A Black Swan in the MoneyMarket," *American Economic Journal: Macroeconomics*, 1 (1), 58-83.

Mollenkamp, C., and M. Whitehouse. (2008), "Study Casts Doubt on Key Lending Rate: WSJ Analysis Suggests Banks May Have Reported Flawed Interest Data for Libor," *Wall Street Journal,* May 29, 2008, p. 1.

Wu, T. (2008), "On the Effectiveness of the Federal Reserve's New Liquidity Facilities," Federal Reserve Bank of Dallas Working Paper No. 2008-08.

Table 1: The Effect of the TAF on the 3-Month LIBOR-Treasury Spread								
	est.	p-value	est.	p-value	est.	p-value	est.	p-value
Cont.	-0.040	0.111	-0.040	0.116	-0.089	0.001	0.060	0.000
β_b	0.415	0.000	0.414	0.000	0.547	0.000	-0.014	0.229
β_i	0.275	0.007	0.275	0.007	0.266	0.002	0.007	0.431
β_r	0.226	0.001	0.225	0.001	0.230	0.000	0.058	0.000
ANI	0.331	0.168	--	--	--	--	--	--
AND	0.115	0.541	--	--	--	--	--	--
ANI+AND	--	--	0.224	0.241	0.281	0.131	0.042	0.082
CON	-0.005	0.968	-0.004	0.975	0.096	0.377	0.016	0.350
AUC	-0.168	0.160	-0.167	0.160	-0.048	0.639	-0.006	0.591
NOT	-0.214	0.121	-0.213	0.108	-0.087	0.375	-0.016	0.136
Wu	--	--	--	--	-0.340	0.012	-0.031	0.058
CDT3	--	--	--	--	--	--	0.928	0.000
$\bar{R}^2$	0.764	--	0.764	--	0.778	--	0.995	--
s.e.	0.172	--	0.172	--	0.166	--	0.026	--



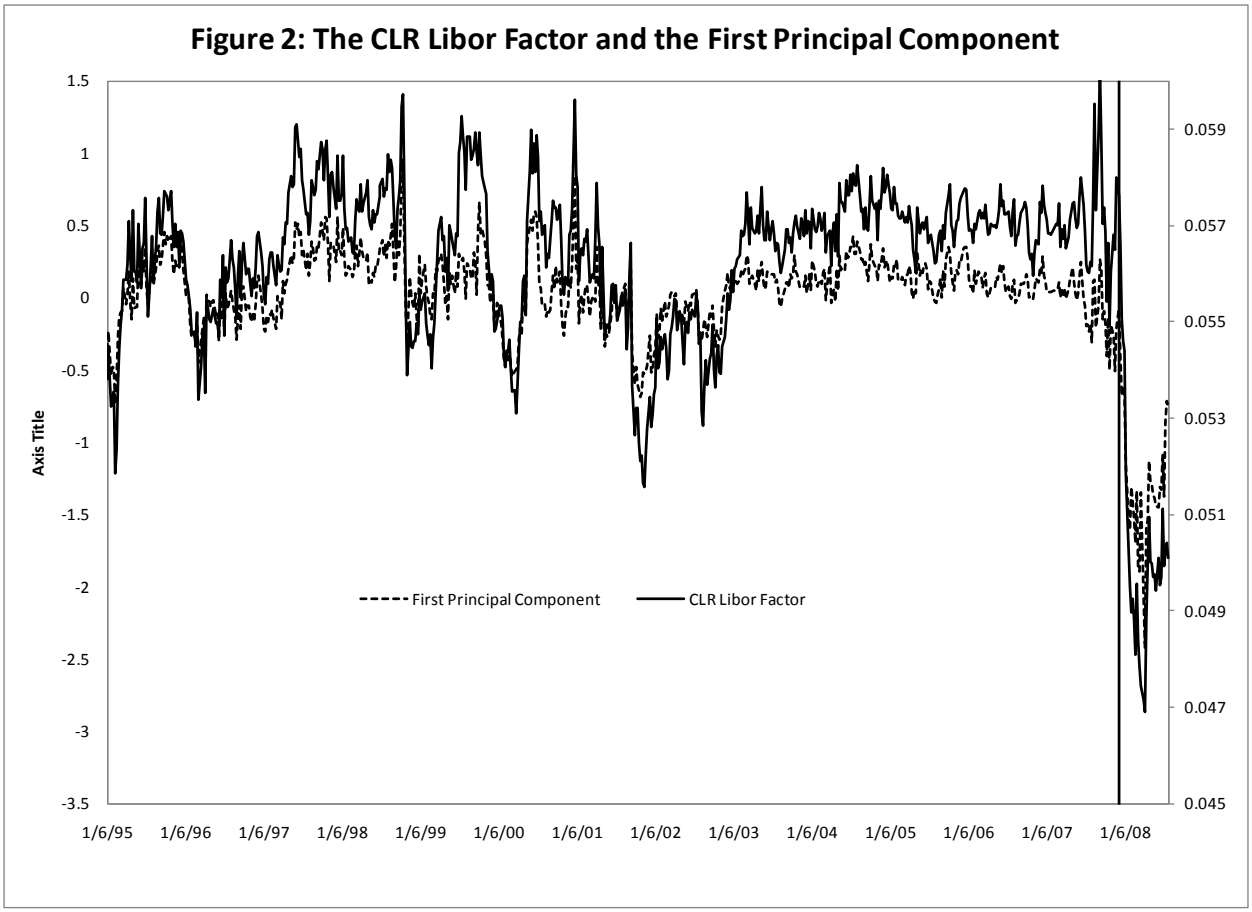


Figure 2: The CLR Libor Factor and the First Principal Component
Axis Title
First Principal Component
CLR Libor Factor
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
0.059
0.057
0.055
0.053
0.051
0.049
0.047
0.045
1/6/95
1/6/96
1/6/97
1/6/98
1/6/99
1/6/00
1/6/01
1/6/02
1/6/03
1/6/04
1/6/05
1/6/06
1/6/07
1/6/08

Figure 3: The 3-Month AA Financial-LIBOR & CD-LIBOR Spreads (January 6, 1995 - July 25, 2008)

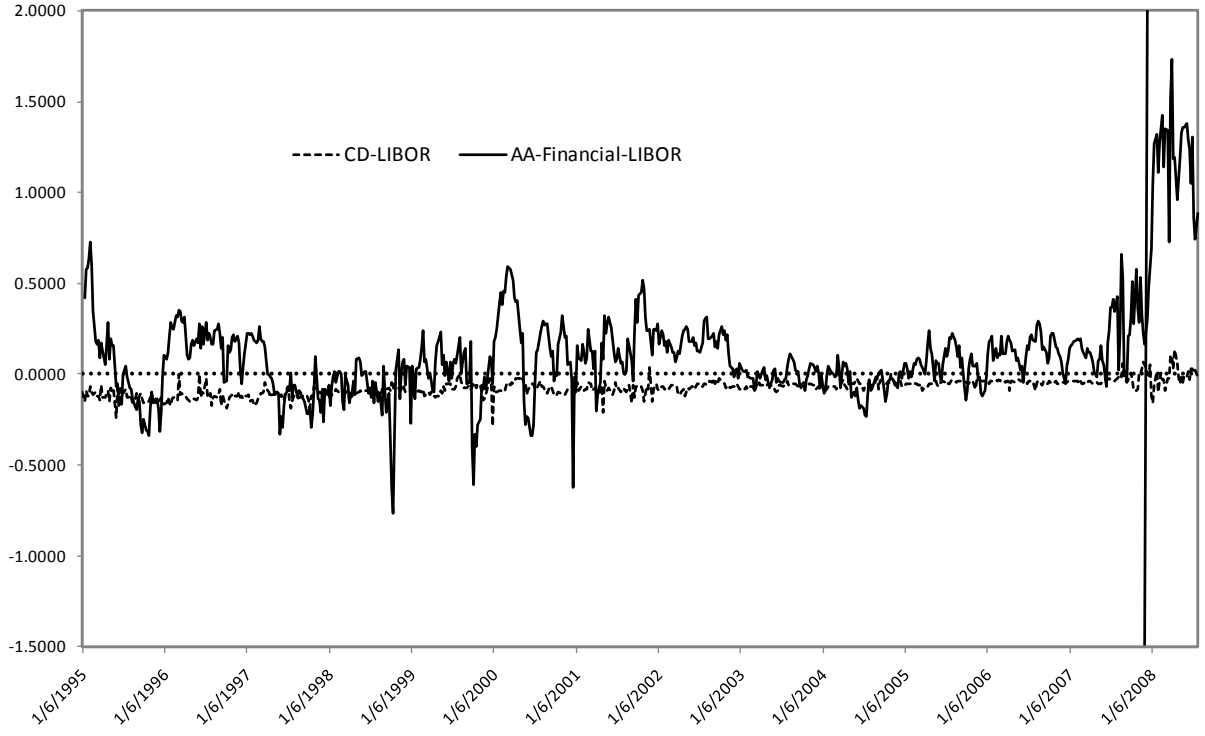


Figure 4: The Spread Between the 3-Month Rates on AA-Rated Financial Bonds and AA-Rated Industrial Bonds

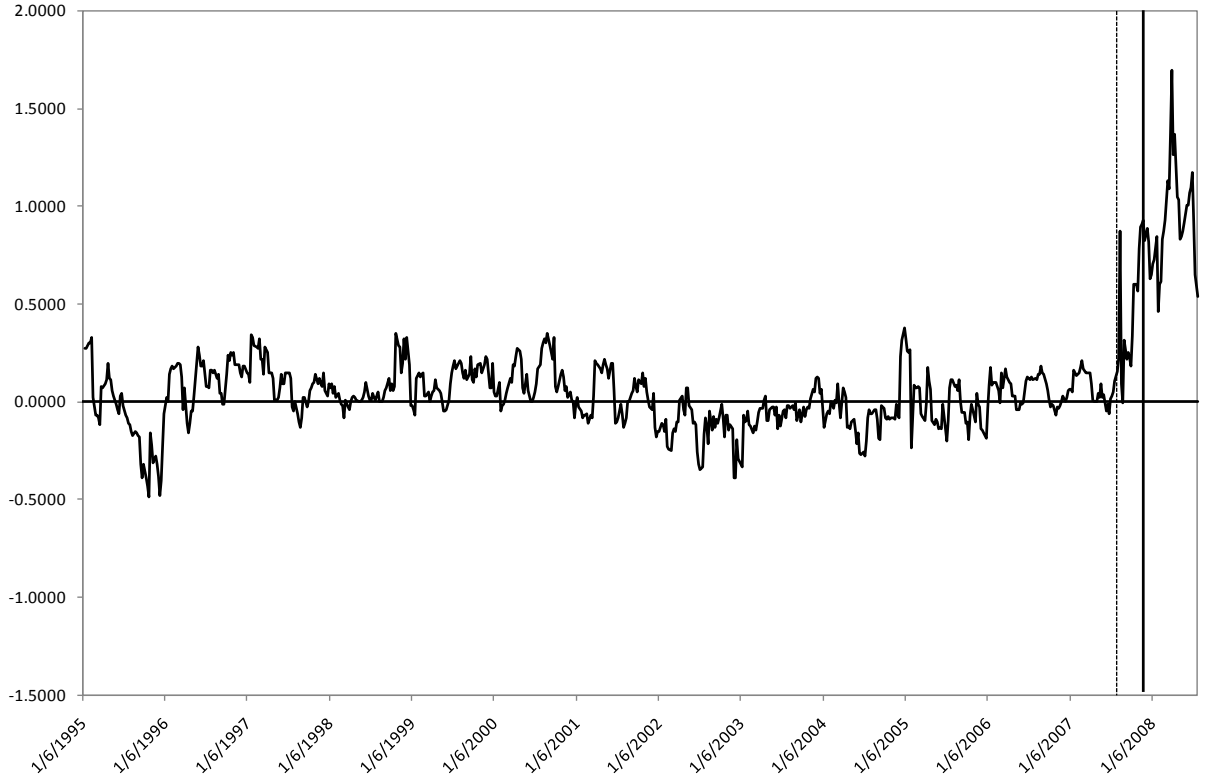


Figure 5: The Spreads Between 3-Month Industrial Bond Rates and 3-Month Libor Rates

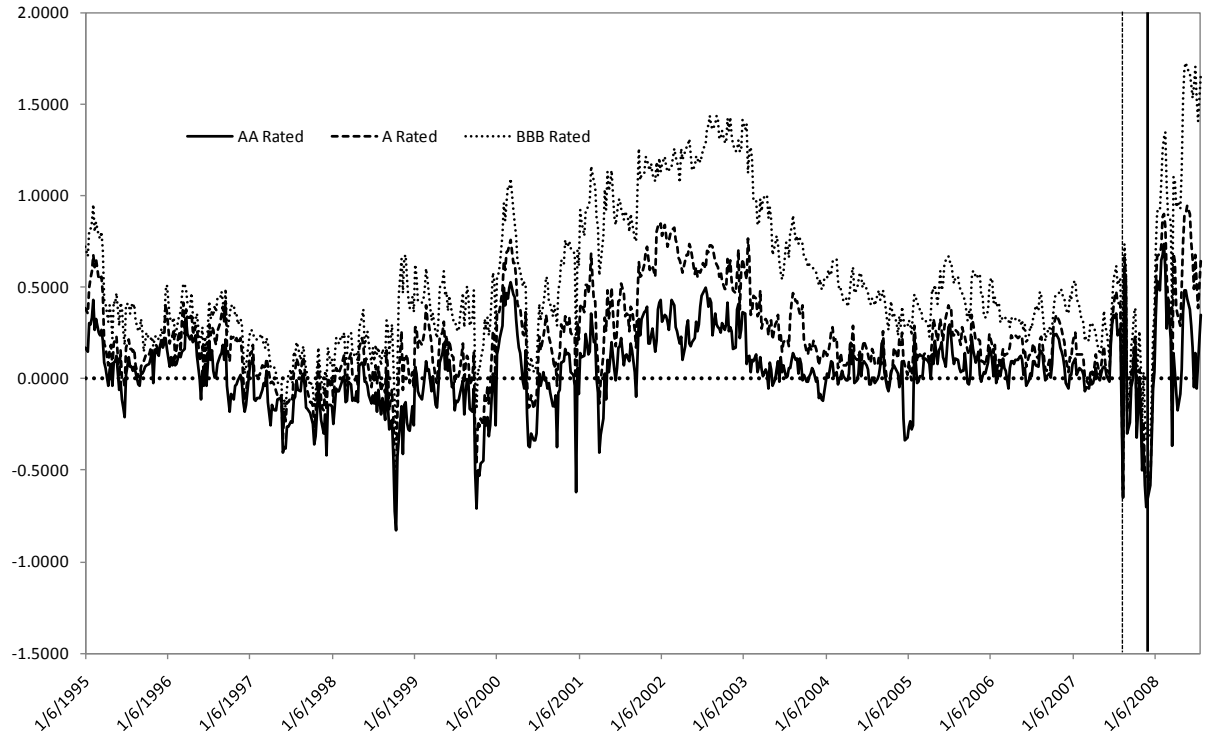


Figure 6: The Spreads Between 3-Month AA-Rated Financial Bonds and BBB-Rate Industrial Bonds and the 3-Month Libor Rate

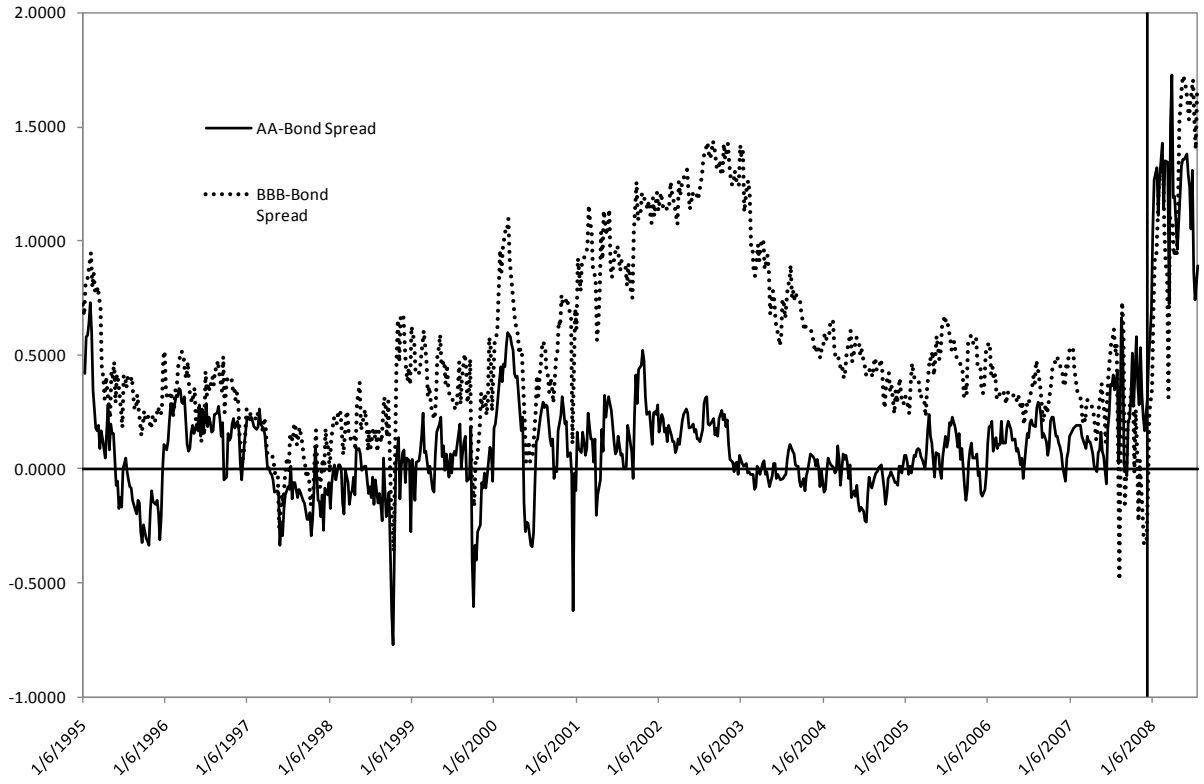


Figure 7: The Spread Between AA-Rated Financial and AA-Rated Bank Bond Rates

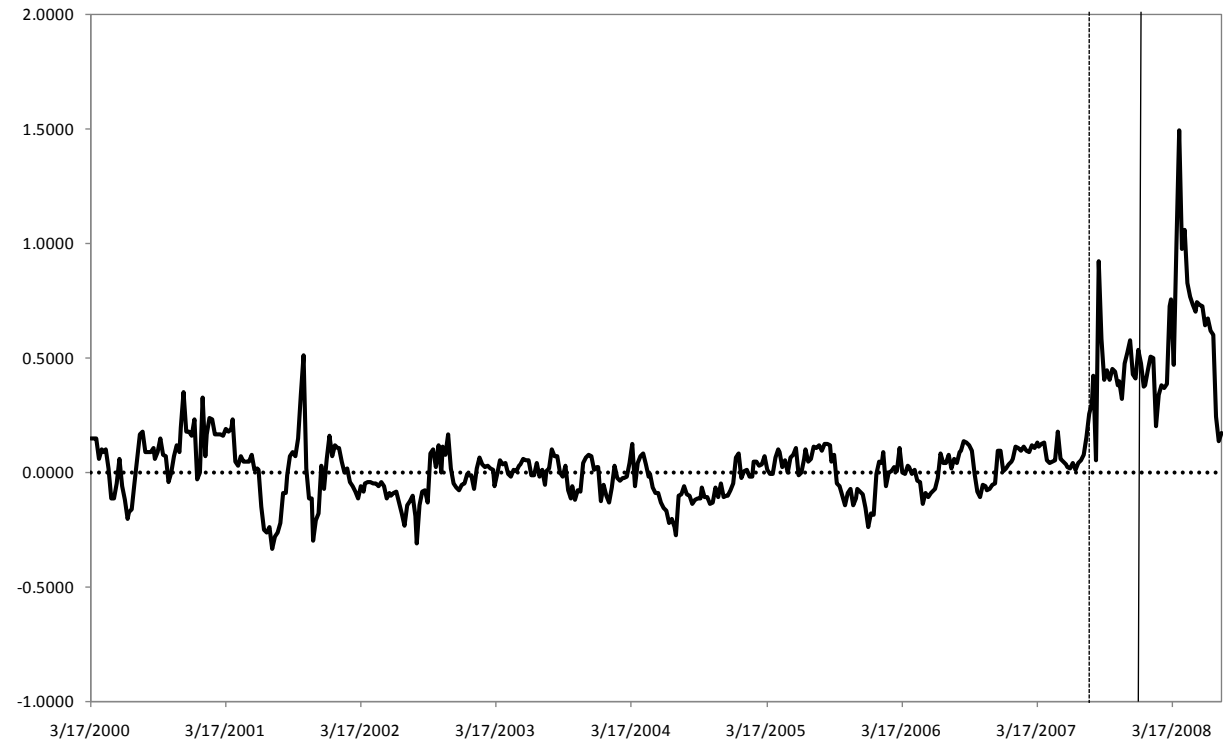
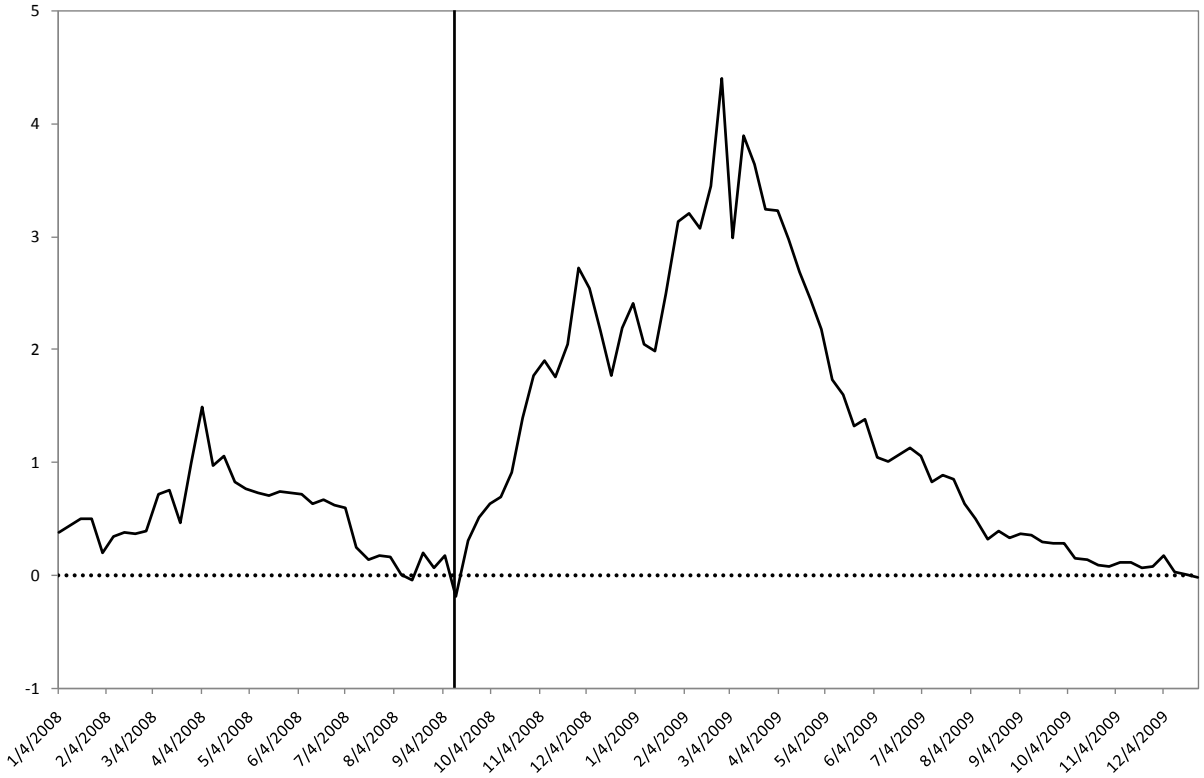


Figure 8: The Spread Between AA-Rated Financial Bonds and AA-Rated Bank Bonds



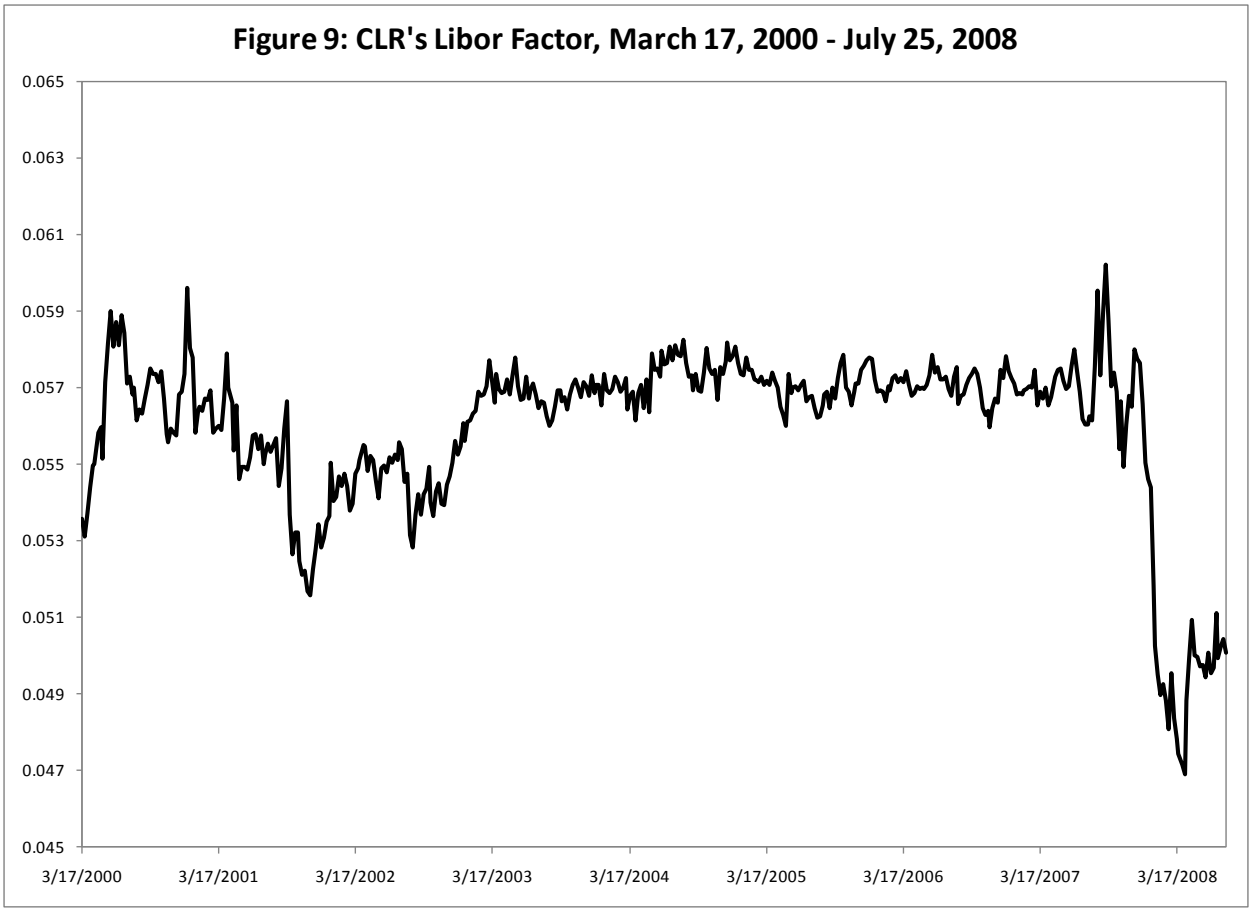


Figure 9: CLR's Libor Factor, March 17, 2000 - July 25, 2008
0.065
0.063
0.061
0.059
0.057
0.055
0.053
0.051
0.049
0.047
0.045
3/17/2000
3/17/2001
3/17/2002
3/17/2003
3/17/2004
3/17/2005
3/17/2006
3/17/2007
3/17/2008

Figure 10: 60-Week-Rolling Estimates of the Adjusted R-square of the CLR Libor Factor on Risk Spreads

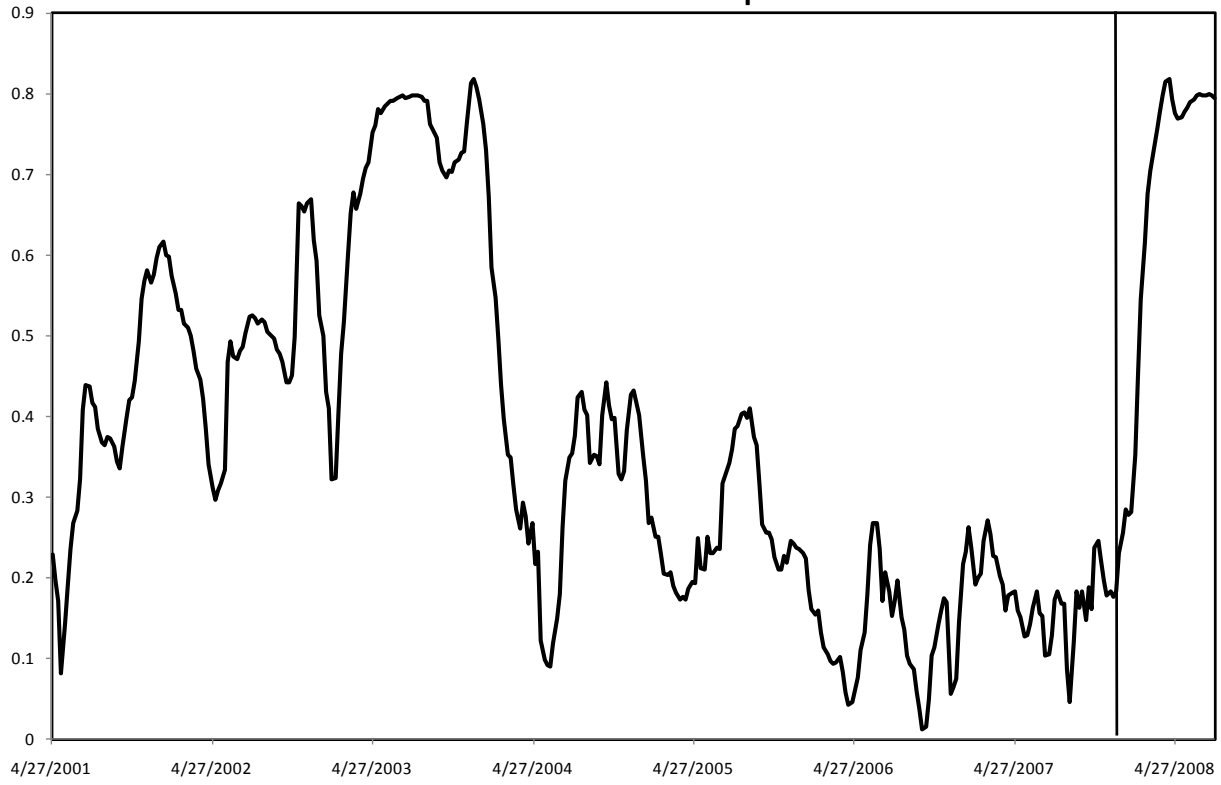


Figure 11: 60-Week-Rolling Estiamtes of the Adjusted R-square of the 3-Month LIBOR-Treasury Spread on Risk Premiums

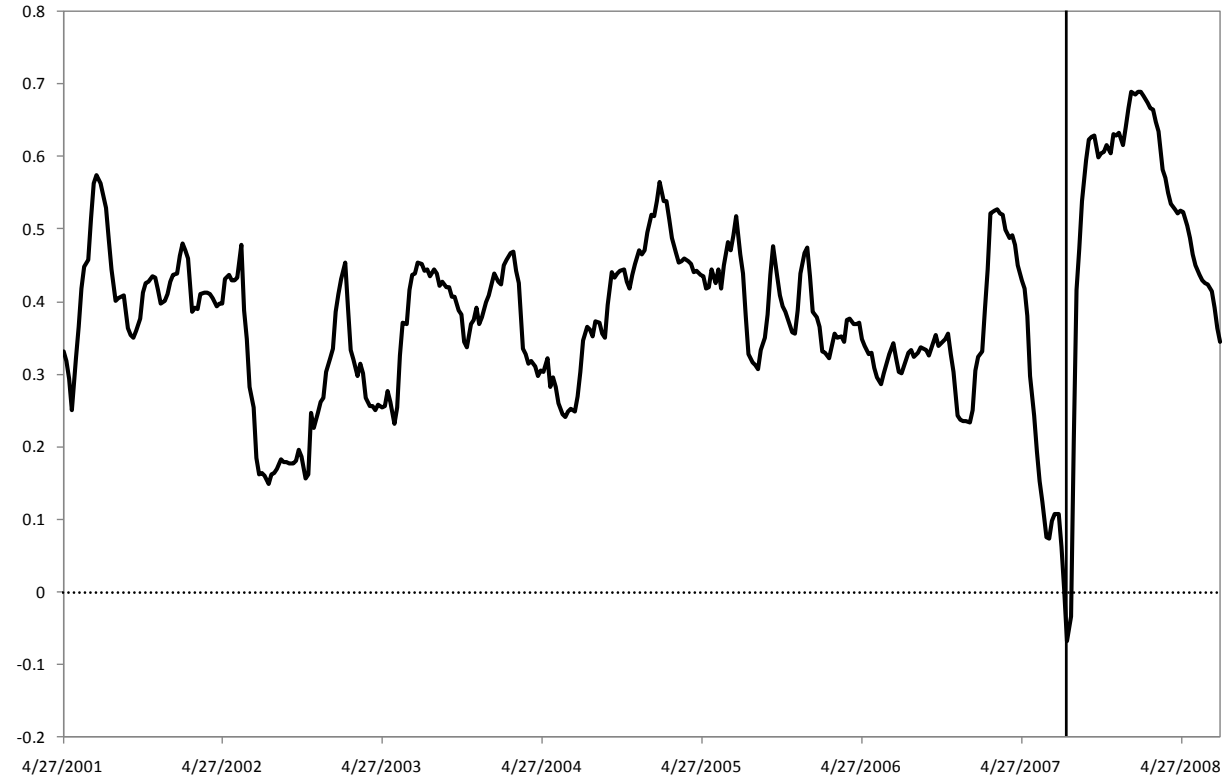


Figure 12: Spreads Between the 3-Month LIBOR and Corporate Rates and the 3-Month T-bill Rate

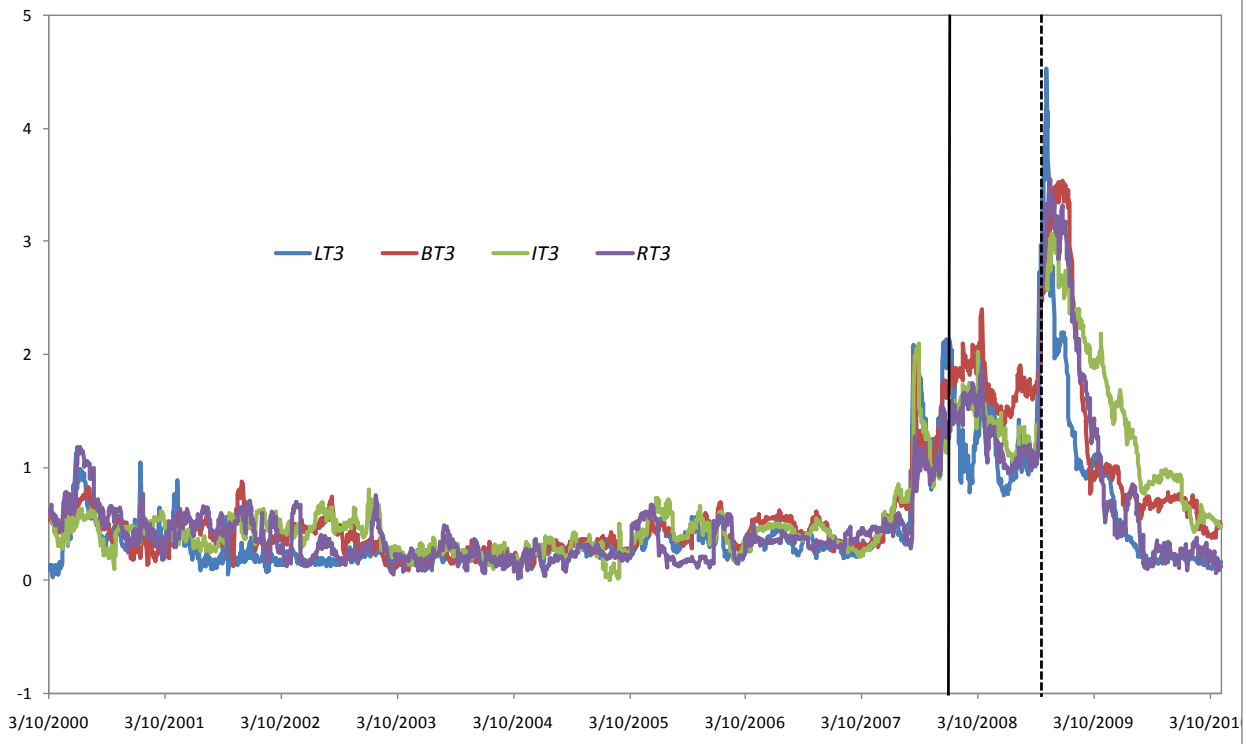


Figure 13: The Spreads Between the 3-Month LIBOR and CD Rates and the 3-Month T-bill Rate